Maintenance and Well Integrity of Aging Gas Storage Assets

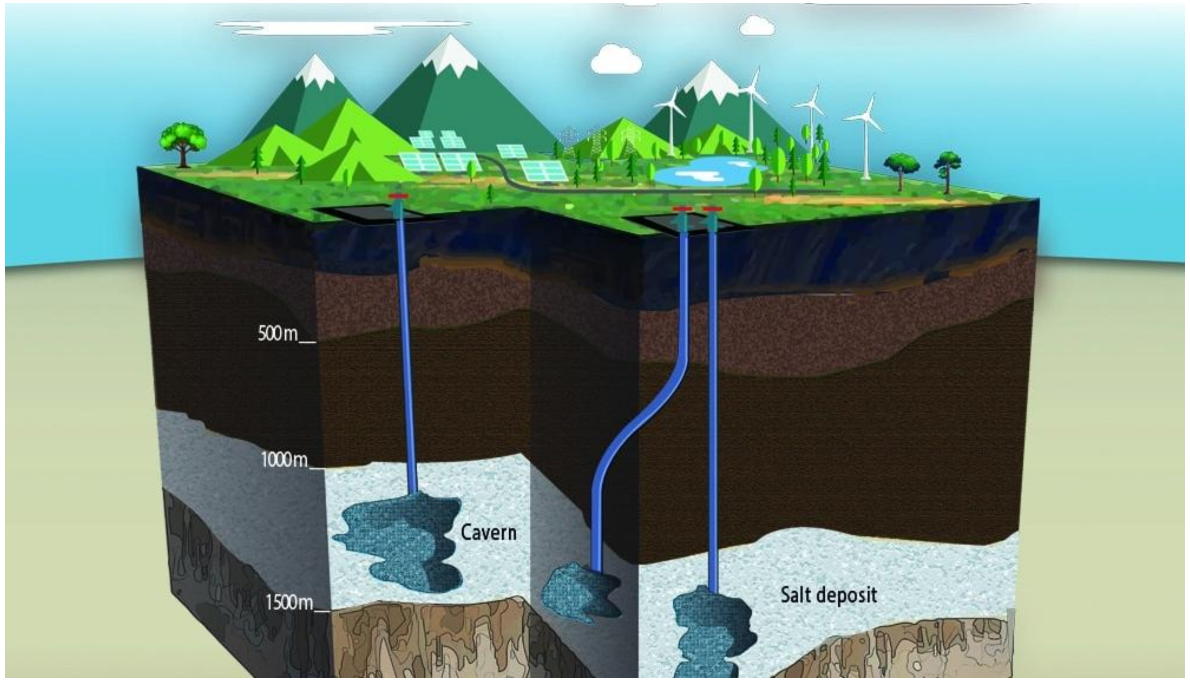
Andy Moffat CEng

18th November 2025

AtkinsRéalis

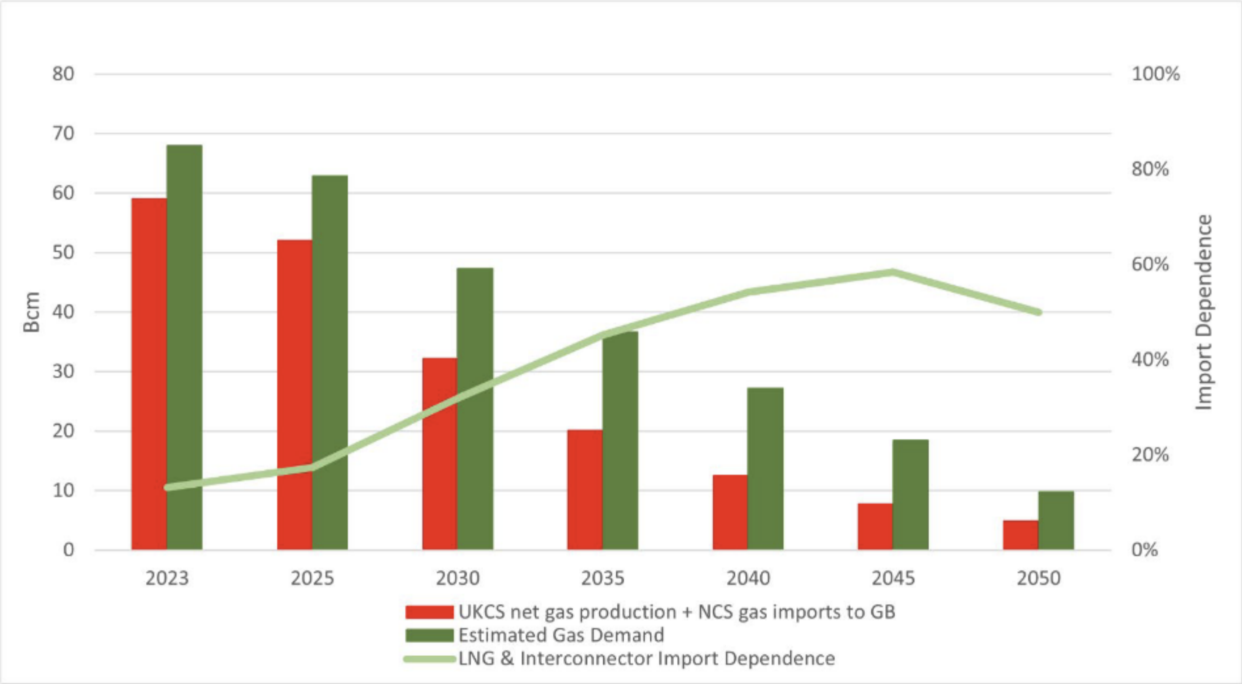
Agenda

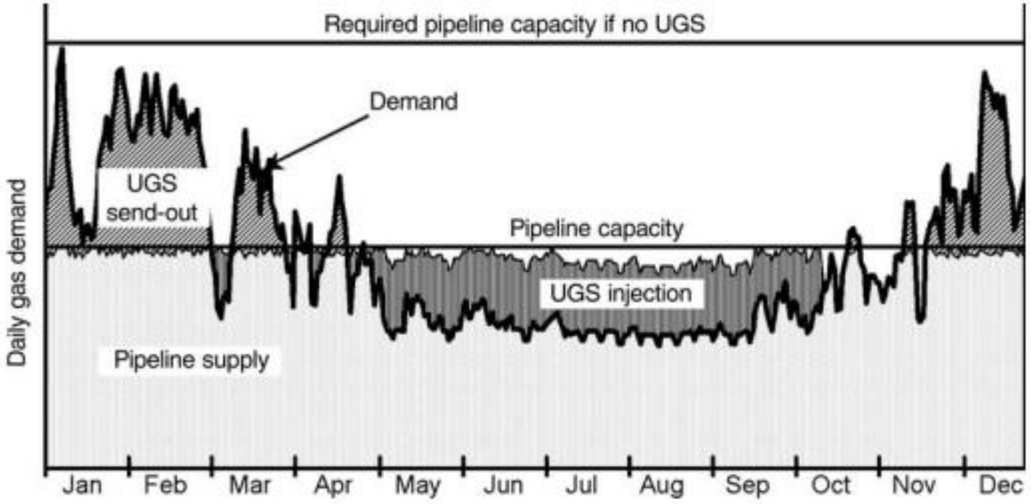
- Role of gas storage in UK energy security
- Capacity of gas storage in the UK
- Types of gas storage in the UK
- Cavern formation & challenges in expanding gas storage reserves
- Unique challenges presented by gas storage caverns
- Conversion of caverns to aid net zero goals



Role of gas storage

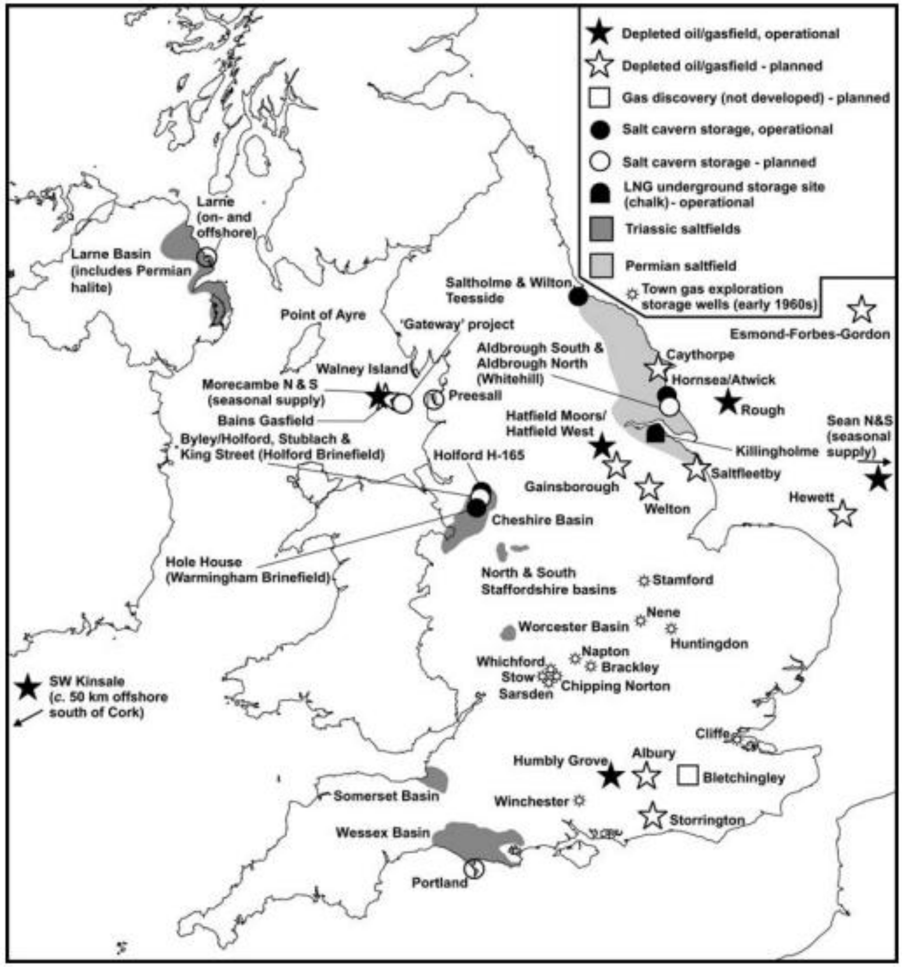
- UK Currently relies on a mixture of sources of natural gas
- Gas use in the UK is forecast to decline as part of 2050 Net zero ambitions
- Gas use and imports will never be eliminated & UKCS is forecast to decrease 10% per year
- UK has storage for approximately 12 days of average gas use (approx. 1 week peak use)
- Storage provides resilience and rapid response during periods of peak demand





Scale of gas storage in the UK

Facility	Volume (mcm)	Max production rate (mcm/d)	Max injection rate (mcm/d)	Withdrawal duration (days)	Start date	Owner
Atwick	308	12	3	26	1979	SSE
Albrough	282	30	26	10	2009	SSE
Hatfield moor	70	2	2	60	2009	Scottish power
Humbly Grove	254	7	8	34	2005	Humbly grove energy
Holford	242	22	2	19	2011	Uniper
Hilltop	59	13	13	5	2011	Kistos
Stublach	400	30	30	13	2014	Storengy
Rough	1500	11	9	>115	2022*	Centrica
TOTAL	**3115**					



Storage types in the UK

Cavern storage

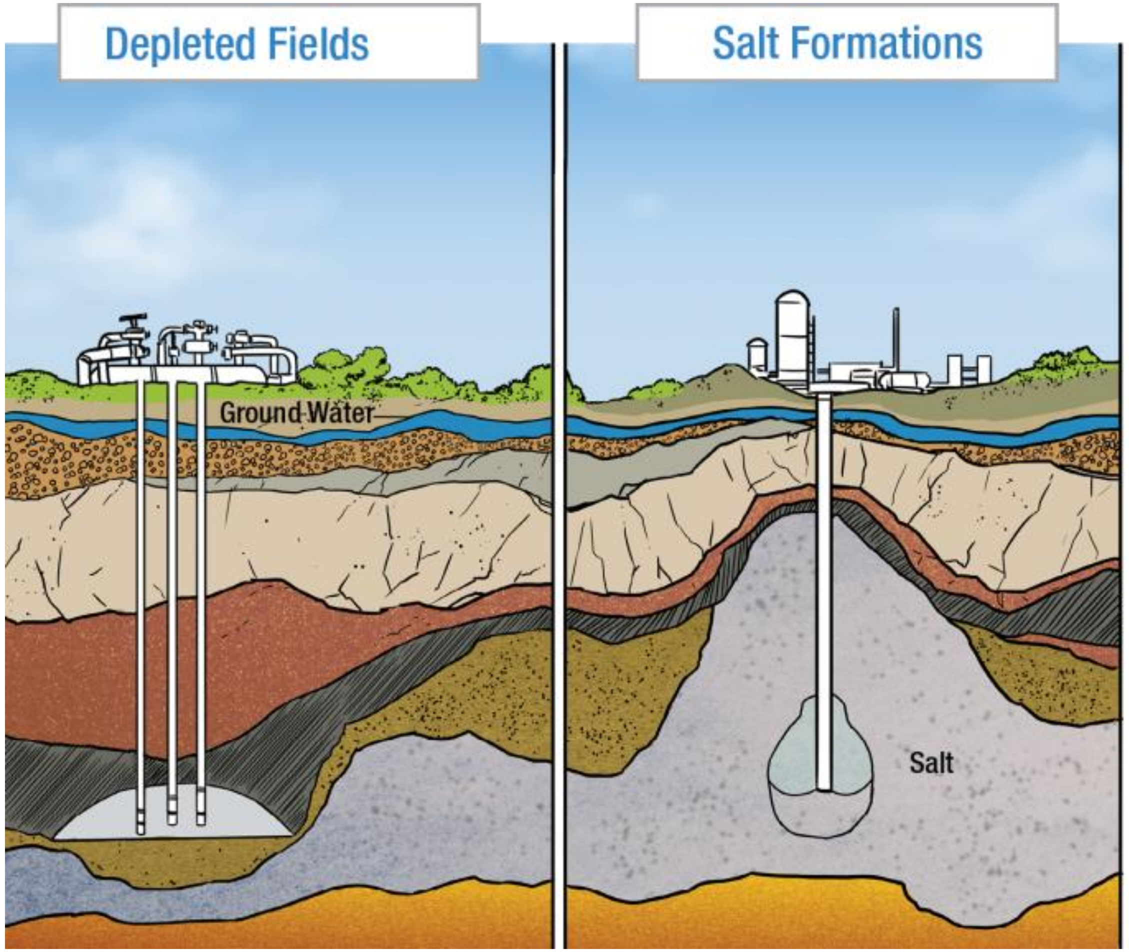
- Allows high injection/withdrawal rates 20-30mcm/d
- Low cushion gas requirements ~20% of capacity

- Comparatively small storage volumes
- Higher CAPEX/OPEX costs

Depleted reservoir storage

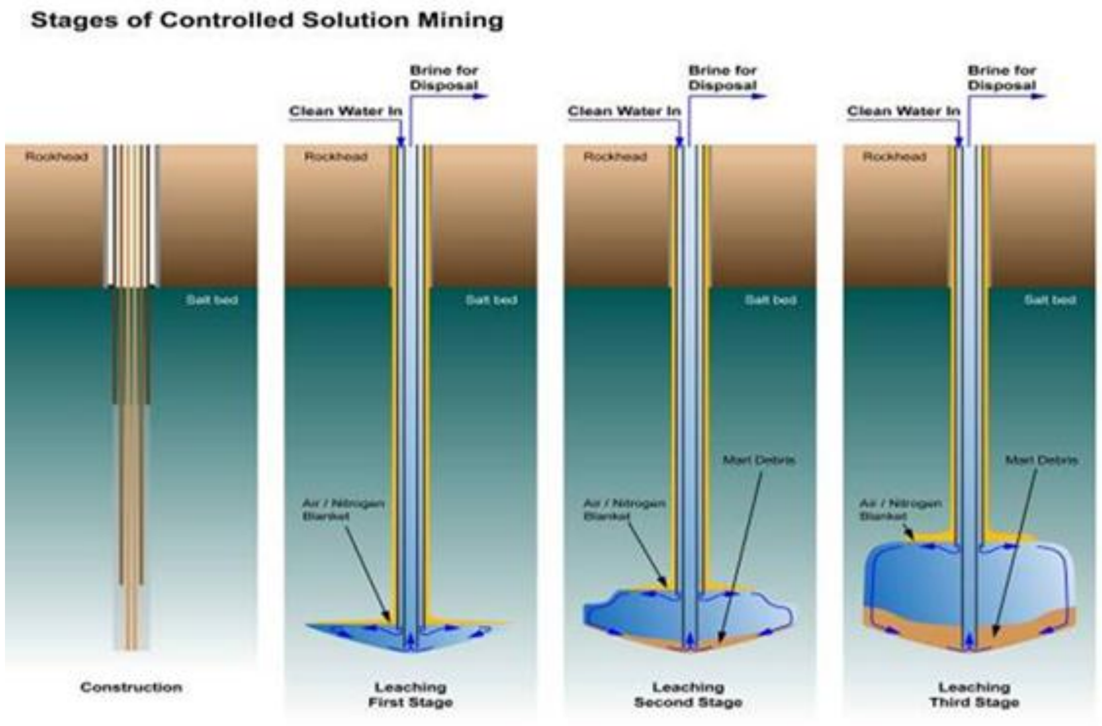
- Existing and understood infrastructure
- Comparatively low cost
- Large capacity

- High cushion gas requirements ~ 45% of capacity
- Slow injection/withdrawal rates 2-10mcm/d
- Risk of solids production



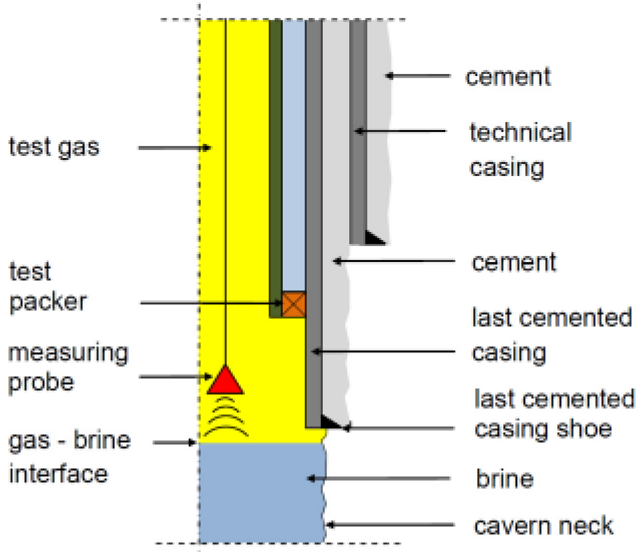
Cavern storage development

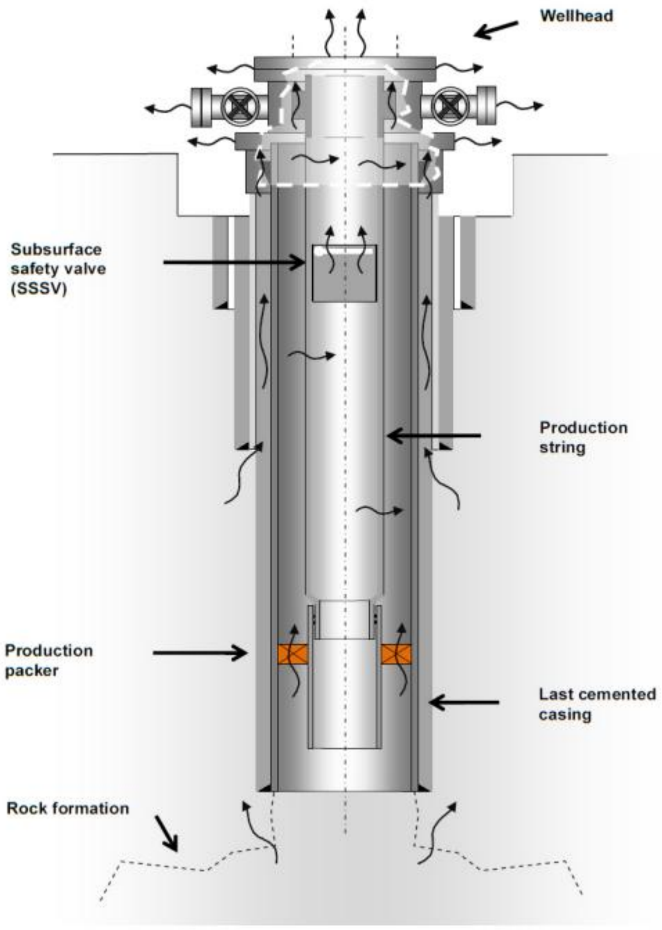
- Well conventionally drilled
- Cavern created through process of leaching (solution mining)
- Injection of fresh or brackish water + brine removed
- Placement of nitrogen or diesel blanket and leaching strings used to control cavern shape and development
- Depending on size, geology, well sizes etc. Caverns can take years to develop
- Pressure maintained within upper/lower bounds dictated by geological conditions
- Injection/extraction limited by geological stresses
- Cavern subject to convergence over time

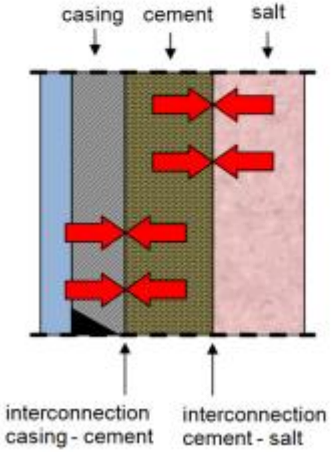


Integrity testing

- Gas storage cavern has similar potential leak paths to conventional gas well i.e. completion tubing, cement, safety valve, wellhead, tree etc.
- Last cemented casing shoe (LCCS) can also be tested via mechanical integrity test (MIT)
- Confirms bond between casing to cement & cement to salt

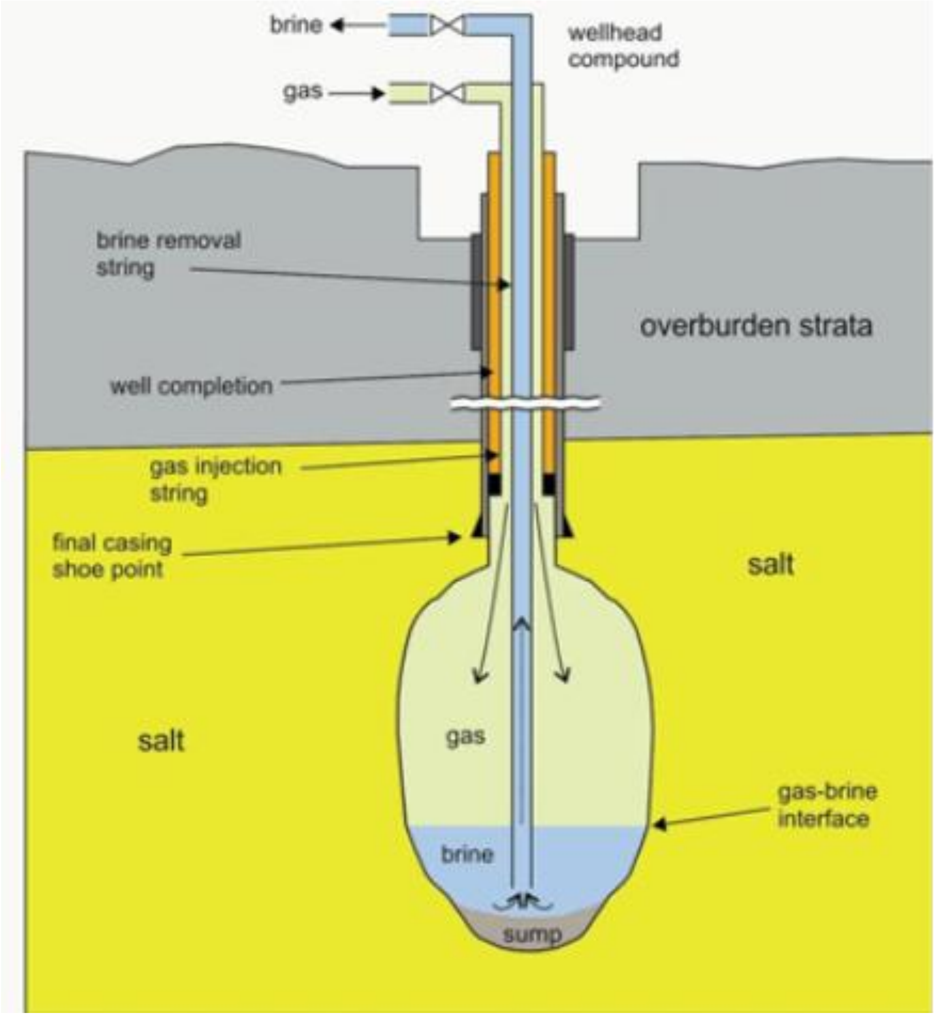






Gas fill process

- De-Brining string installed down to bottom of cavern
- Gas injected via completion/de-brining string annulus
- Brine returns taken through de-brining string to surface and disposed of
- De-brining string snubbed out of well & cavern put into service



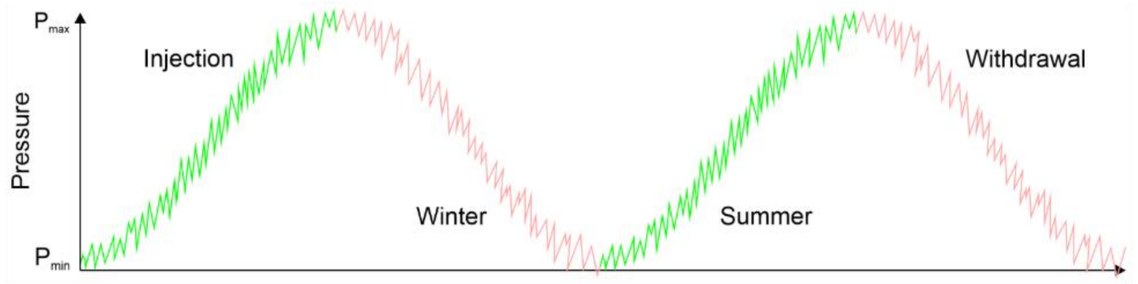
Consequences uncontrolled release

- Failure of de-brining tubing during gas break through
- Fire self extinguished after approximately 7 days
- Loss of approximately 170 million sm^3 of natural gas
- Cavern & gas replacement value – estimated $50-55m

Seasonal use & cyclic loading

- Conventional wells typically have a declining pressure trend
- Gas storage wells have cyclic pressure regimes
- Periods of demand, gas is withdrawn and cavern pressure reduced
- Periods of excess production, gas is injected and stored, increasing pressure
- Generally follow a seasonal tend
- Withdrawal in winter
- Injection in summer
- May also fluctuate daily due to market forces
- Pmin - Pmax dictated by geomechanics
- Daily rate of change dictated by geomechanics

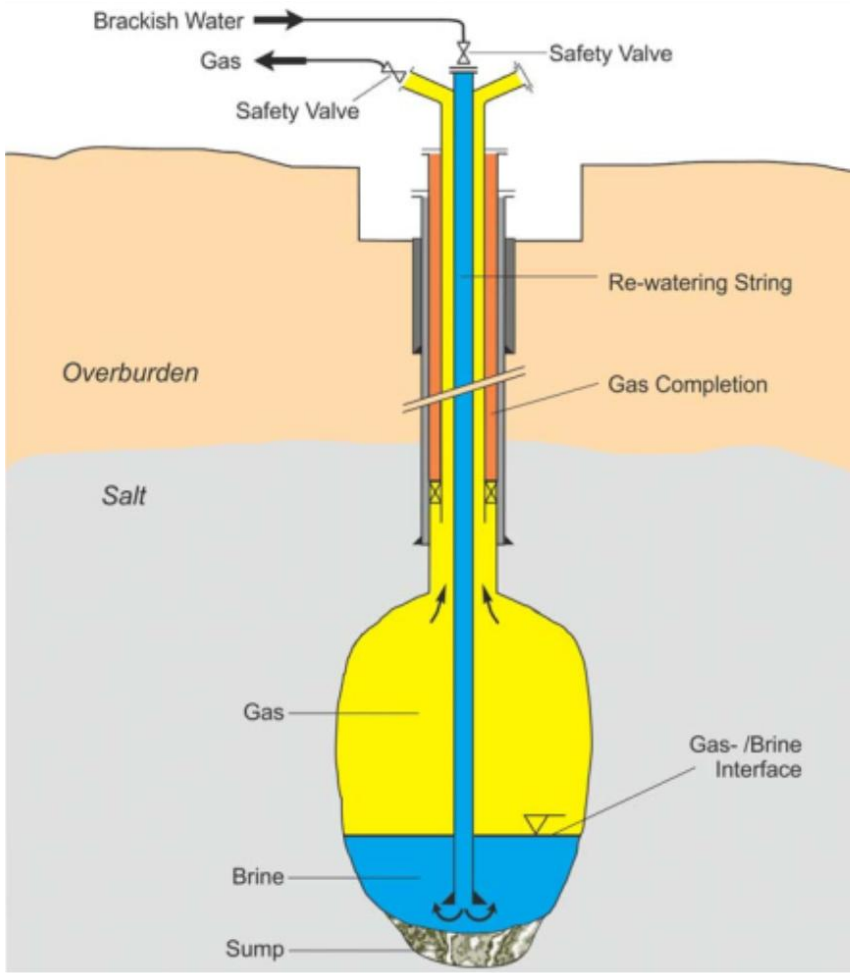
- Cyclic loading can increase mechanical and thermal stresses on all barrier elements



Well kill

- Unable to kill the well conventionally
- Cavern must be re-watered to remove gas and ensure cavern stability
- Rewatering string snubbed into the cavern
- Fluid pumped through rewatering string & gas returns through new annulus
- Flow rate limited by fluid velocity in free hanging pipe
- Process can take months of pumping work depending on cavern size

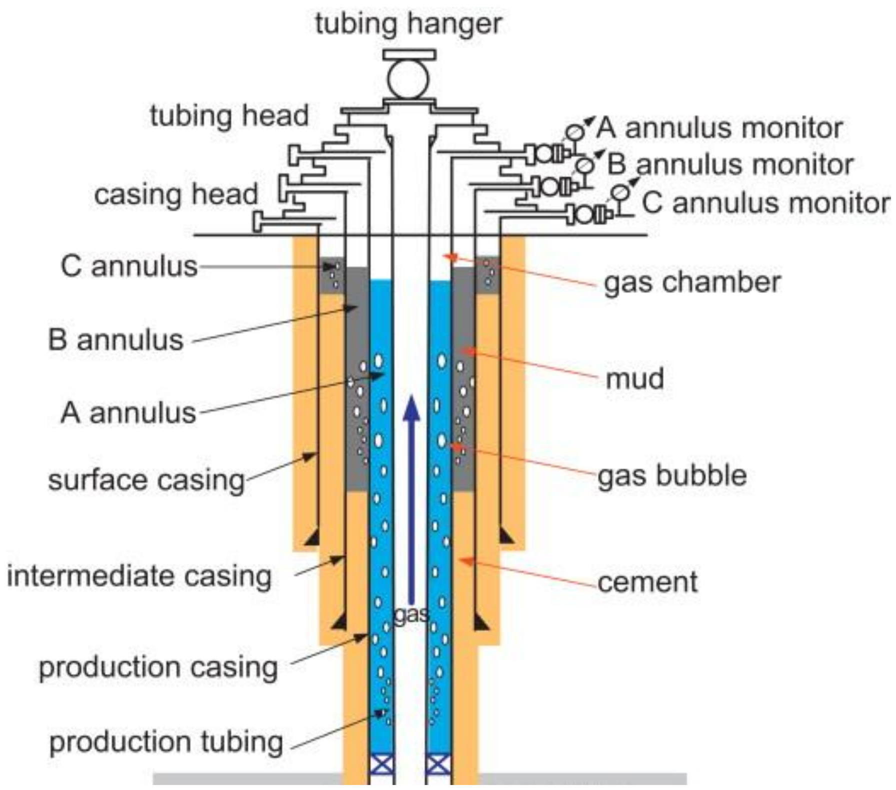
- Final abandonment can take years – thermal effects and cavern leaching/convergence
- High cost for equipment, personnel, sourcing of fluids etc.



Remediation

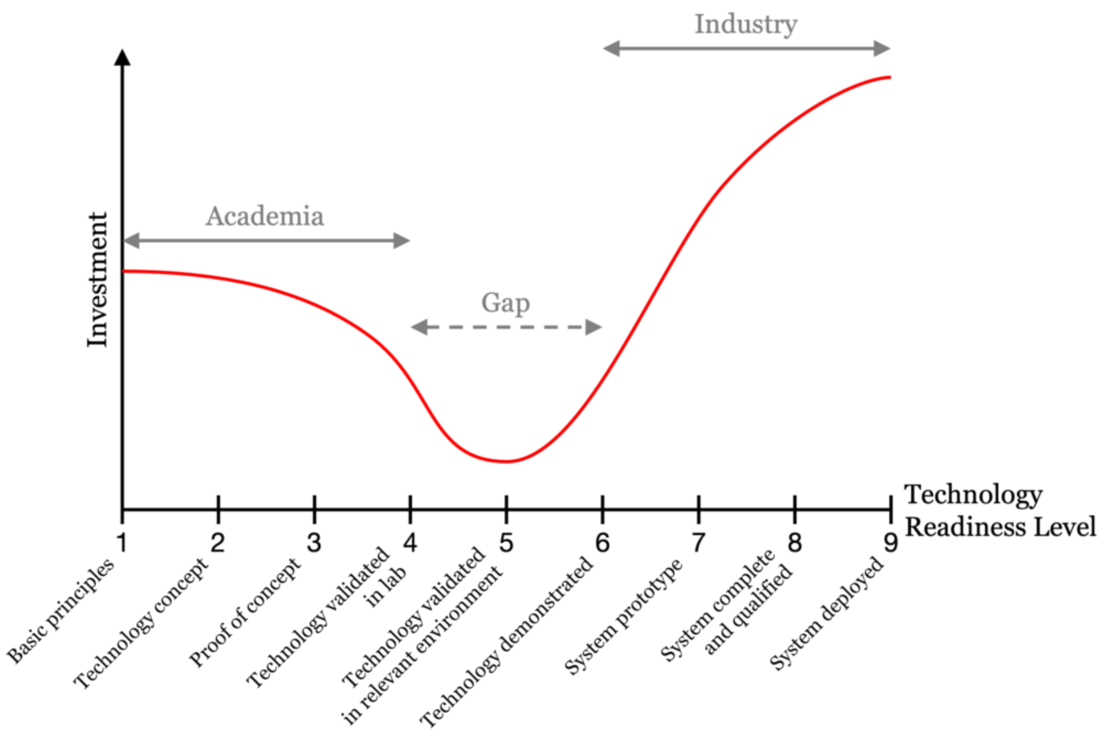
- Well kill requires months of pumping to displace all gas from cavern
- Well control issues can be repaired with conventional plugs, straddles, flow control devices etc.
- Additional consideration required for selection of equipment
- Cyclic loading & extended service life

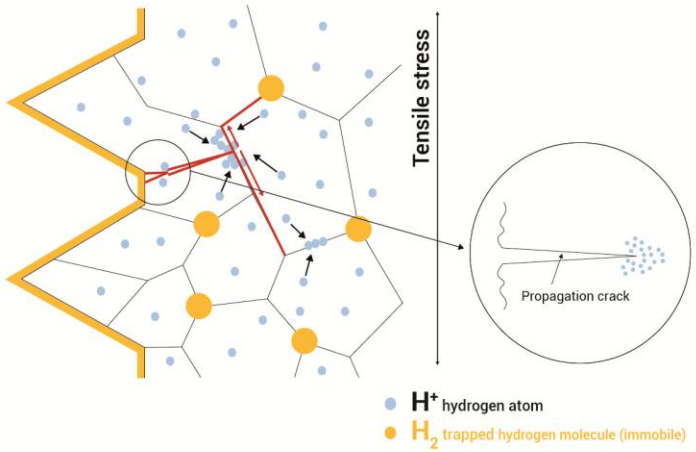
- Recompletion often requires rewatering of cavern – an operation which can take several months to complete



Hydrogen storage

- Existing cavern storage assets may be converted to Hydrogen storage
- Caverns acting as buffer storage for intermittent renewable energy supply
- Hydrogen behaviour within wells is in its infancy
- Suitability of critical barrier elements still to be proven
- Further engineering and development required to bridge the gap
- Limited standards & guidance to use for development





thank you

AtkinsRéalis